ADA

ALTERNATIVE FUELS COMPATIBILITY WITH ARMY EQUIPMENT TESTING – AGED NIEDNER RIFTS CONDUIT TESTING

INTERIM REPORT
TFLRF No. 426

by

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Structural Engineering Department

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San Antonio, TX

for

U.S. Army TARDEC
Force Projection Technologies
Warren, Michigan

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14. ABSTRACT

The objective of this project was to perform burst and cyclic testing on an aged Niedner RIFTS conduit from Fort Lee, and then compare these results with the unaged baseline results from Niedner RIFTS testing performed by SwRI in 2006. Burst testing is used to establish the working pressure of the aged conduit, while cyclic testing is used to represent repeated deployment and retrieval in the field, and determine effects it will have on the burst and working pressure of the hose. Eight 15-foot specimens were extracted from a 500-foot reel of aged Niedner RIFTS conduit for burst testing and cyclic testing. When compared to the previous results, the aged Niedner conduit has a working pressure 100 psig less than that of the unaged baseline conduit. It was also noted that the cyclic testing had less effect on the burst pressure of the aged conduit than the unaged baseline conduit.

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EXECUTIVE SUMMARY

Two reels of naturally aged Niedner RIFTS conduit were available for testing at Fort Lee, Virginia. Both reels contained approximately 500 feet of hose with a manufacturing date of July 2005. The Niedner conduit was part of a previous RIFTS testing program at Southwest Research Institute (SwRI). Since manufacturing, the hose had been exposed to diesel fuel as well as outdoor environmental conditions. The objective of this project was to perform burst and cyclic testing on an aged Niedner RIFTS conduit from Fort Lee, and then compare these results with the unaged baseline results from Niedner RIFTS testing performed by SwRI in 2006. Burst testing was used to establish the working pressure of the aged conduit, while cyclic testing was used to represent repeated deployment and retrieval in the field, and determine the effects it will have on the burst and working pressure of the hose. Eight 15-foot specimens were extracted from a 500-foot reel of aged Niedner RIFTS conduit for testing. When compared to the previous results, the aged Niedner conduit had a working pressure 100 psig less than that of the unaged baseline conduit. It was also noted that the cyclic testing had less effect on the burst pressure of the aged conduit than the unaged baseline conduit.

FOREWORD/ACKNOWLEDGMENTS

The U.S. Army TARDEC Fuel and Lubricants Research Facility (TFLRF) located at Southwest Research Institute (SwRI), San Antonio, Texas, performed this work during the period December 22, 2010 through February 21, 2012 under Contract No. W56HZV-09-C-0100. The U.S. Army Tank Automotive RD&E Center, Force Projection Technologies, Warren, Michigan administered the project. Mr. Luis Villahermosa (AMSRD-TAR-D/MS110) served as the TARDEC contracting officer's technical representative. Mr. David Green, and Mr. Eric Sattler, of TARDEC served as project technical monitors.

The authors would like to acknowledge the contribution of the TFLRF technical support staff along with the administrative and report-processing support provided by Dianna Barrera and Rita Sanchez.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (CONTINUED)

1.0 INTRODUCTION AND OBJECTIVES

1.1 INTRODUCTION

Two reels of naturally aged Niedner RIFTS conduit were available for testing at Fort Lee, Virginia. Both reels contained approximately 500 feet of hose with a manufacturing date of July 2005. The Niedner conduit was part of a previous RIFTS testing program at Southwest Research Institute (SwRI). Since manufacturing, the hose had been exposed to diesel fuel as well as outdoor environmental conditions. Due to the aged condition of the hose, TARDEC desired burst and cyclic tests to be conducted to determine whether there were any detrimental effects on the performance of the hose. The hose reels were shipped to SwRI for testing. Results from the previous tests (SwRI project no. 09.06848) were used as an unaged baseline comparison.

1.2 OBJECTIVE

The objective of this project was to perform burst and cyclic testing on the aged Niedner RIFTS conduit from Fort Lee, and then compare these results with the unaged baseline results from Niedner RIFTS testing performed by SwRI in 2006. Burst testing is used to establish the working pressure of the aged conduit, while cyclic testing is used to represent repeated deployment and retrieval in the field, and determine effects it will have on the burst and working pressure of the hose. Comparison of these results with the 2006 testing results from SwRI project number 09.06848, shows any effects the aging has had on the performance of the conduit.

2.0 SPECIMEN PREPARATION AND INSPECTION

2.1 SPECIMEN EXTRACTIONS

The two reels of hose delivered to SwRI from Fort Lee are shown in Figure 1. One reel of hose, shown on the right, was used to extract specimens for burst and cyclic testing.

Figure 1. Hose Reels as Delivered to SwRI

The hose was unreeled and a total of eight specimens were cut. The hose was first cut approximately two feet from the end fitting, and then specimens labeled A through H, each approximately 15 feet long, were cut in order, with A closest to the end fitting. All cuts were made with a portable band saw for efficiency and consistency. Figure 2 through Figure 4 illustrate the specimen extraction process.

Figure 2. Unreeling of Hose before Cutting Specimens

Figure 3. Cutting a Specimen with Portable Band Saw

Figure 4. Specimens after Cutting

2.2 SPECIMEN INSPECTIONS

The eight specimens cut from the hose reel were measured and inspected for damage. When measuring the specimens approximately 3 hours after the specimens had been cut, it was noted that the outer jacket and the inner liner were no longer even. For this reason, measurements of both the jacket and liner were recorded for each specimen. These measurements are provided below in Table 1, along with notes of any damage present. It would appear, based on the original cut length of 15 feet, that the liners expanded. Figure 5 shows the specimens just after inspection. Figure 6 shows the ends of the stacked specimens, where the difference in length of the jackets and liners is clearly visible.

Table 1. Lengths of Hose Specimens and Inspection Notes

Hose Specimen	Length of Jacket (inches)	Length of Liner (inches)	Notes
A	180 $^1/_4$	181 $^1/_2$	Tear in outer layer of jacket
B	180	181	No damage noted
C	179 $^1/_2$	181 $^1/_4$	Abrasion in outer layer of jacket
D	180	181 $^1/_2$	No damage noted
E	180 $^1/_4$	182	No damage noted
F	180 $^1/_2$	181 $^3/_4$	No damage noted
G	180 $^1/_4$	181 $^1/_2$	No damage noted
H	180 $^1/_2$	182 $^1/_4$	No damage noted
All hoses had a nominal diameter of 6 inches.			

Figure 5. Hose Specimens After Inspection

Figure 6. Liner Expansion after Cutting Specimens

The condition of all of the cut specimens was soiled but otherwise good, with the exception of specimens A and C. There was a small hole in the outer layer of the jacket of specimen A as shown in Figure 7. This was located 60 inches from one end of specimen A. The damage to specimen C was a less significant abrasion to the outer layer of the jacket located 9 inches from one end, shown in Figure 8. Neither of the anomalies were considered to be major damage that would exclude the specimens from testing; therefore, no actions were taken to repair or remove the damage. The notes from the specimen preparation and inspection are presented in Appendix A.

Figure 7. Hole in Outer Layer of Jacket of Specimen A

Figure 8. Abrasion to Outer Layer of Jacket of Specimen C

2.3 END FITTING ASSEMBLY

Before performing any testing on the hose specimens, end fittings were assembled on each end. The procedure followed for assembling the end fittings is presented in Table 2. The only variation from this procedure was that the hardware for specimen A was torqued to 45 ft-lbs, whereas all subsequent specimen end fittings were torqued to 40 ft-lbs. This change was due to the limitations of the hardware being used (3/8-24 x 2 ½" grade L9). The end fitting assembly process is summarized in Figure 9 through Figure 12.

Table 2. End Fitting Assembly Procedure

Step No.	Description
1	Cut the Aramid jackets and bladder lining equally across one side of the conduit section and trim any excess Aramid yarns.
2	Apply lubricant to both the inside of the conduit section (bladder) and to the exterior mating surface of the shank.
3	With the aid of a wooden striking surface, insert the shank into the conduit section leaving no more than a 1-inch gap between the flange face and the end of the conduit.
4	Lightly bolt two sets of collars together with three bolts each, forming 2 collar halves. Be sure to use new grade L9 bolts and nuts. A washer should be used on both ends of bolts.
5	Align the 2 collar halves together around the ridged end of the inserted shank. Be sure to properly align the ridges of the collars to those of the inserted shank, and ensure the tapered side of the collars is facing the length of the conduit section.
6	Lightly bolt the 2 collar halves together on one side only, then clamp the other side of the 2 collar halves together using 3-inch C-clamps and tighten until that side can be lightly bolted together.
7	After all bolts have been inserted, gradually tighten all bolts equally to 40 ft-lbs (do NOT lubricate bolts). Be sure to maintain equal spacing between the collars, then attach a lock nut to each bolt.

Figure 9. End Fitting Shank and Collars

Figure 10. Inserting Shank into Conduit

Figure 11. Installing End Fitting Collars

Figure 12. Assembled End Fitting

3.0 BURST TESTING

Burst testing was performed to determine both the ultimate pressure load the conduit can withstand, as well as the conduit working pressure. The working pressure was calculated from the average burst pressure using a 3-to-1 factor of safety. Four of the hose specimens (A, B, C, and D) were burst in the same condition as they were extracted from the hose reel; no other testing was performed on these specimens. The remaining specimens (E, F, G, and H) underwent cyclic testing before being burst. The results of all of the burst tests are presented below. The notes on calibration of the pressure transducer used for burst testing are presented in Appendix B.

3.1 BURST TESTING PROCEDURE

The steps of the burst testing procedure are presented below in Table 3. For those specimens that underwent cyclic testing before being burst, some of these steps had already been completed as part of the cyclic testing procedure.

Table 3. Burst Testing Procedure

Step No.	Description
1	End plugs should be installed on both ends of the conduit using IPDS couplings to attach them to the conduit end fittings.
2	Setup the plumbing for the pump to pressurize the conduit.
3	Setup the data acquisition system (DAS) and check for proper operation, with a scan interval no greater than 1 Hz.
4	Visually inspect the conduit section and document the conduit's condition on the data sheet. The conduit should be supported by the PVC rollers along the length of the section.
5	Ensure that the conduit section is not twisted.
6	Photograph the test setup from multiple angles making sure at least one photo shows the entire test sample.
7	Attach the water inlet line, pressure transducer line, and thermocouples to the end plugs.
8	Fill the conduit with water and purge as much air as practical from the conduit (approximately 60 psig in hose).
9	Close the inlet and exit water lines.
10	With approximately 60 psig (city water pressure) in the hose, measure the length of the conduit length overall (LOA) and length of hose between collars (free length) with the measuring tape (document on data sheet).
11	Make sure that the video cameras are positioned correctly to record the burst.
12	Ensure that all personnel have cleared the area before proceeding and that proper means have been taken to warn/prevent bystanders from approaching testing facilities.
13	Record the filename on the data sheet and make sure that there is adequate media to video record the burst test.
14	Activate DAS and video recorder. After checking for proper operation, turn on the pump.
15	Increase pressure on the conduit at a continuous rate. The target rate of increase is 1000 psig per minute.
16	Allow the conduit section to burst and record the burst pressure.
17	Turn off the pump and de-activate the DAS and video recorder. Label the video file/tape.
18	Visually examine the conduit and take photographic records. Also, note the condition of the conduit on the data sheet.
19	Record the date and burst pressure on the conduit section with a paint pen.

3.2 BURST TESTING RESULTS

The results of the burst testing are presented below in Table 4, along with an indication of which specimens underwent cyclic testing prior to burst testing. The length presented in Table 4 is that of just the conduit, as if the end fittings were not there, pressurized to approximately 60 psig. Note that all specimens failed due to a longitudinal tear of the jacket weft threads that occurred on or very near the crease made when the hose is lying flat. There were no end fitting failures. Neither specimen A nor C failed at or near the damage noted in section 2.2. The data sheets from the burst testing are presented in Appendix C.

Table 4. Summary of Burst Testing Results

Specimen	Length (inches)[1]	Burst Pressure (psig)	Failure Mode	Underwent Cyclic Testing
A	182 1/2	1504	Longitudinal tear of jacket and liner	No
B	180	1610	Longitudinal tear of jacket and liner	No
C	181 1/2	1886	Longitudinal tear of jacket and liner, small transverse tear of liner	No
D	181 1/2	1767	Longitudinal tear of jacket and liner	No
E	186 1/16	1324	Longitudinal tear of jacket and liner	Yes
F	184 1/2	1712	Longitudinal tear of jacket and liner	Yes
G	184 3/4	1680	Longitudinal tear of jacket and liner	Yes
H	187	1534	Longitudinal tear of jacket, blowout of liner	Yes

[1]Measured length of conduit pressurized to approximately 60 psig

The average burst pressure of the four specimens that were not cycled (A, B, C, and D) was 1,692 psig, with a standard deviation of 169 psig. Applying the 3-to-1 safety factor yields a working pressure of 564 psig, which was rounded down to a nominal value of 550 psig. This working pressure was used for the cyclic testing of the remaining specimens (E, F, G, and H), which is described in section 4.0. After cycling, the average burst pressure of the four remaining specimens was 1,563 psig, with a standard deviation of 177 psig. Therefore, the cyclic testing reduced the average burst pressure of four specimens by 129 psig, which is equivalent to a 43 psig reduction in working pressure. It should be noted, however, that the average burst pressure for each group of specimens is within the standard deviation of the other. Regardless, the cyclic testing did appear to have a clear effect on the performance of the specimens. Of the four cycled specimens, the burst failure of three occurred in the region that underwent bending cycles. Also, significant elongation occurred due to the pressure cycles. The burst testing setup and associated failure of each specimen

is presented in Figure 13 through Figure 35. The data time-history graphs for each test are presented in Appendix D.

Figure 13. Specimen A Burst Testing Setup

Figure 14. Specimen A Burst Testing Failure

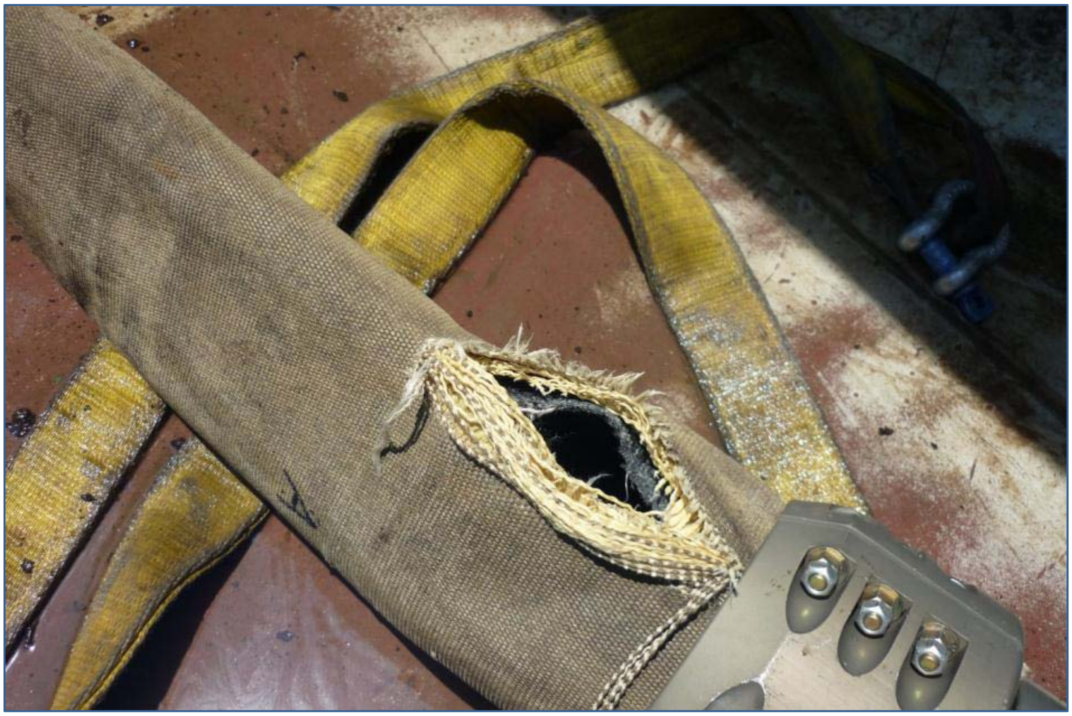

Figure 15. Specimen A Burst Testing Failure Close-Up

Figure 16. Specimen B Burst Testing Setup

Figure 17. Specimen B Burst Testing Failure Close-Up

Figure 18. Specimen C Burst Testing Setup

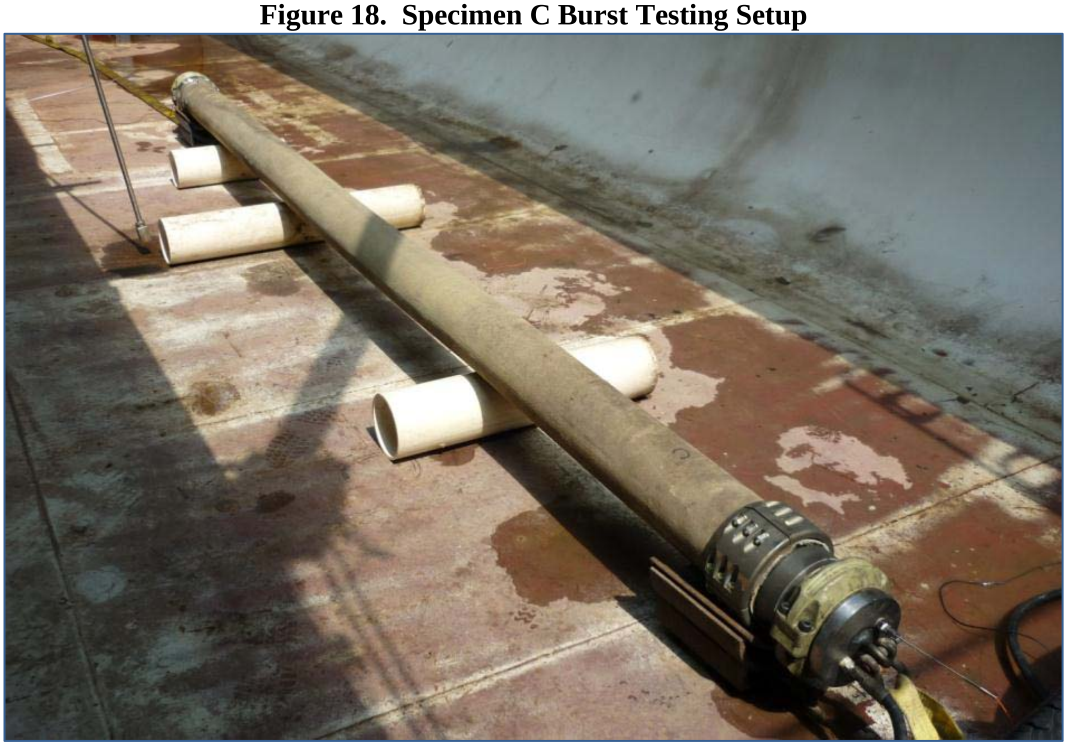

Figure 19. Specimen C Burst Testing Failure

Figure 20. Specimen C Burst Testing Failure Close-Up

Figure 21. Specimen D Burst Testing Setup

Figure 22. Specimen D Burst Testing Failure

Figure 23. Specimen D Burst Testing Failure Close-Up

Figure 24. Specimen E Burst Testing Setup

Figure 25. Specimen E Burst Testing Failure

Figure 26. Specimen E Burst Testing Failure Close-Up

Figure 27. Specimen F Burst Testing Setup

Figure 28. Specimen F Burst Testing Failure

Figure 29. Specimen F Burst Testing Failure Close-Up

Figure 30. Specimen G Burst Testing Setup

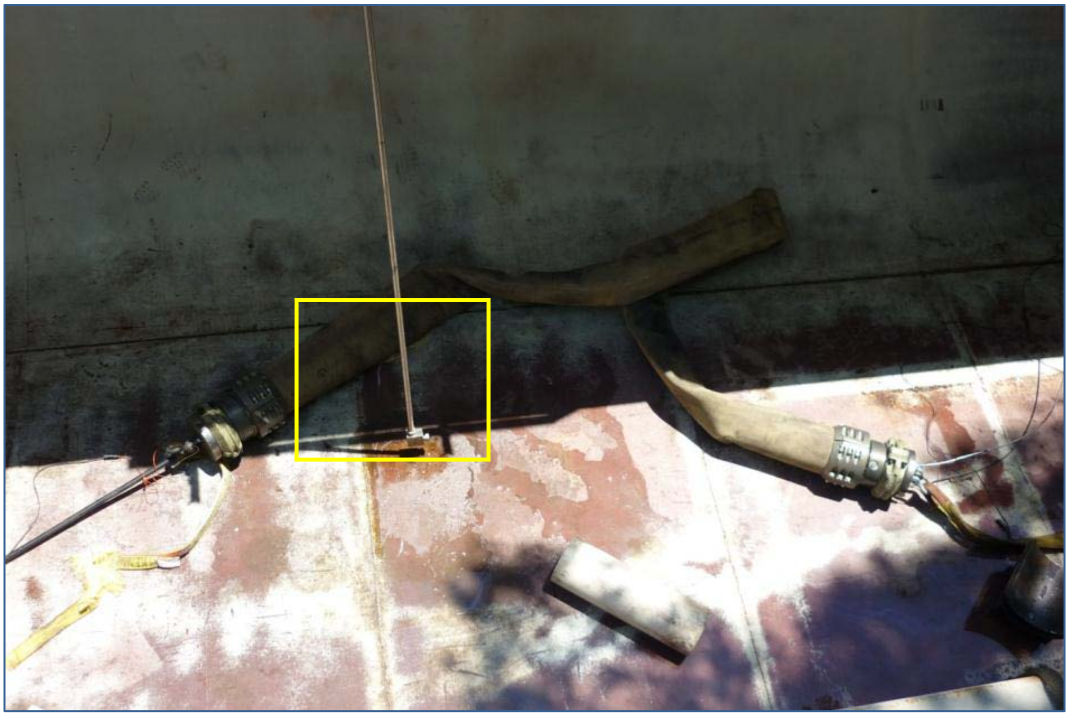

Figure 31. Specimen G Burst Testing Failure

Figure 32. Specimen G Burst Testing Failure Close-Up

Figure 33. Specimen H Burst Testing Setup

Figure 34. Specimen H Burst Testing Failure

Figure 35. Specimen H Burst Testing Failure Close-Up

4.0 CYCLIC TESTING

Cyclic testing was performed to simulate the conditions experienced by the actual conduit due to deployment and retrieval in the field. This testing involved both alternating bending cycles and pressurization cycles. The bending cycles were performed by threading the hose specimen around a small (3-inch) and large (36-inch) roller. One end of the specimen was connected to a 142-lb dead weight and the other to a winch, allowing a portion of the specimen to be cycled through the rollers. The bending cycle fixture is shown in Figure 36 and Figure 37. For the pressurization cycles, a working pressure of 550 psig was used. See Appendix B for calibration information on the pressure transducer used for pressurization cycles. Cyclic testing was performed on specimens E, F, G, and H before undergoing burst testing.

Figure 36. Bending Cycle Fixture

Figure 37. Bending Cycle Fixture Close-Up

4.1 CYCLIC TESTING PROCEDURE

The cyclic testing procedure is presented in Table 5. For specimens E, F, G, and H, the burst testing procedure, described in section 3.0 of this report, immediately followed cyclic testing.

Table 5. Cyclic Testing Procedure

Step No.	Description
1	End Plugs should be installed on both ends of the conduit using IPDS couplings to attach them to the conduit end fittings.
2	Measure the length of the conduit with the measuring tape (document on data sheet).
3	Ensure that the couplings are properly installed on each end of the conduit section.
4	Visually inspect the conduit section and document the conduit’s condition on the data sheet.
Bending Cycles	
5	Thread the conduit into the bending cycle fixture. If there is wording on only one side of the conduit, position the conduit section with the wording facing away from the 36” roller.
6	Attach the counterweight to the free end of the conduit section and attach the other end to the winch.
7	Mark the extreme positions of the hose for reference when performing the cyclic testing (8” from coupling – start of 3” roller, 49” from coupling – start of 36” roller).
8	Photograph the test setup from multiple angles making sure at least one photo shows the entire test sample.
9	Ensure that only the winch operator is in close proximity to the testing apparatus before proceeding and that proper means have been taken to warn/prevent bystanders from approaching testing facilities.
10	Commence cyclic testing and subject the conduit to 100 bending cycles. Indicate the completion of the bending cycles on the data sheet and include the date.
11	Remove the conduit from the bending cycle fixture and transfer the conduit to the pressure testing site.
Pressurization Cycles	
12	End Plugs should be installed on both ends of the conduit using IPDS couplings to attach them to the conduit end fittings.
13	Set up the plumbing for the pump to pressurize the conduit.
14	Setup the data acquisition system (DAS) and check for proper operation, with a scan interval no greater than 1 Hz.
15	Visually inspect the conduit section and document the conduit's condition on the data sheet. The conduit should be supported by the PVC rollers along the length of the section.
16	Ensure that the conduit section is not twisted.
17	Photograph the test setup from multiple angles making sure at least one photo shows the entire test sample.
18	Attach the water inlet line, pressure transducer line, and the thermocouples to the end plugs.
19	Fill the conduit with water and purge as much air as practical from the conduit (approximately 60 psig in hose).
20	Close the inlet and exit water lines.
21	With approximately 60 psig (city water pressure) in the hose, measure the conduit length overall (LOA) and length of hose between collars (free length) with the measuring tape (document on data sheet).
22	Make sure that the video cameras are positioned correctly to record the subsequent burst. It is not necessary to record video of the pressure cycles.
23	Ensure that all personnel have cleared the area before proceeding and that proper means have been taken to warn/prevent bystanders from approaching testing facilities.
24	Record the filename on the data sheet.
25	Activate DAS.
26	Turn on the pump and check the DAS system for proper operation.
27	Pressurize the conduit to the working pressure (min) then back down to 60 psig (min) for a total of 20 pressure cycles. Indicate the completion of the pressure cycles on the data sheet and include the date. De-activate the DAS.
28	After completing all 20 cycles, with approximately 60 psig in the hose, measure the conduit length overall (LOA) and length of hose between collars (free length) with the measuring tape (document on data sheet).

4.2 CYCLIC TESTING RESULTS

Specimens E, F, G, and H underwent bending and pressurization cyclic testing without sustaining any considerable damage or failures; however, some effects were noted as a result of the testing. The bending cycles introduced additional creases on the specimens caused by the small (3-inch) roller, and three of these specimens failed in this region when burst. This effect is shown below in Figure 38. The pressurization cycles brought about a notable change in length for each specimen. These results are presented in Table 6. As with the previous measurements, these lengths are of the conduit (as if the end fittings were not there) pressurized to approximately 60 psig. The data sheets from the cyclic testing are provided in Appendix C.

Figure 38. Creases Caused by Bending Cycles

Table 6. Change in Length from Pressurization Cycles

Hose Specimen	Length Before (inches)[1]	Length After (inches)[1]	Notes
E	182	$186\ {}^{1}/_{16}$	20 pressurization cycles to 550 psig
F	182	$184\ {}^{1}/_{2}$	20 pressurization cycles to 550 psig
G	$181\ {}^{7}/_{8}$	$184\ {}^{3}/_{4}$	20 pressurization cycles to 550 psig
H	184	187	20 pressurization cycles to 550 psig

[1]Measured length of conduit pressurized to approximately 60 psig

After completing cyclic testing, specimens E, F, G, and H were burst and those results have been presented in section 3.2. The cyclic testing resulted in a reduction of 129 psig of the average burst pressure when compared to the uncycled specimens. Figure 39 through Figure 46 show the bending and pressurization setup for each specimen. The data time-history graphs of the pressurizations cycles can be found in Appendix D.

Figure 39. Specimen E Bending Cycles Setup

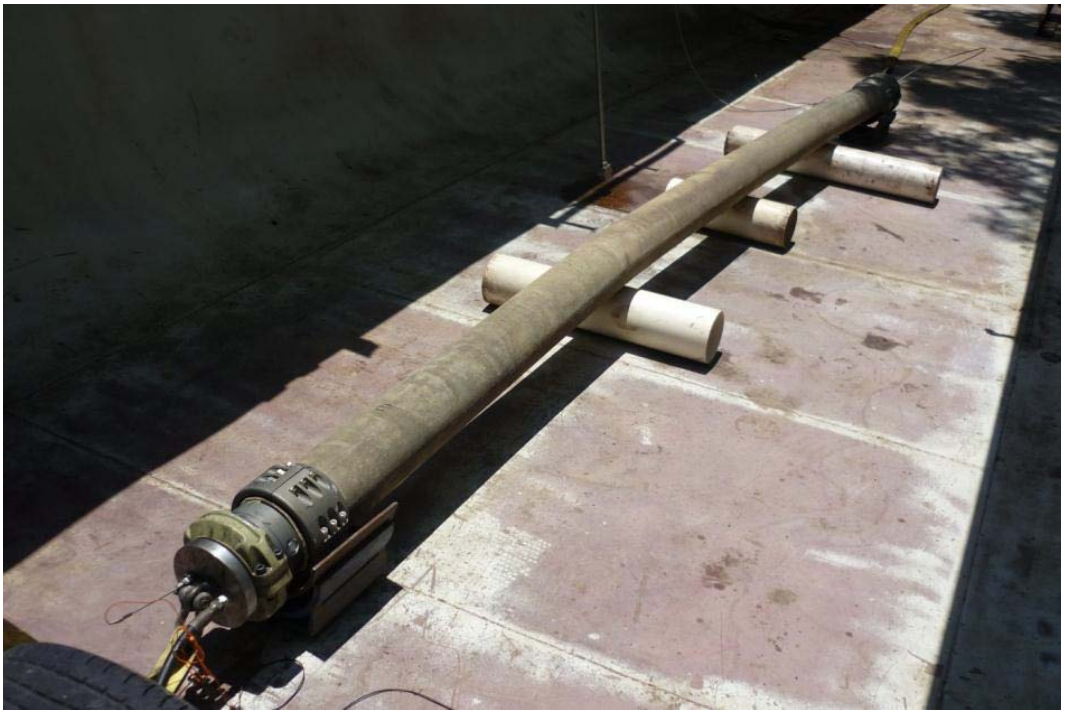

Figure 40. Specimen E Pressurization Cycles Setup

Figure 41. Specimen F Bending Cycles Setup

Figure 42. Specimen F Pressurization Cycles Setup

Figure 43. Specimen G Bending Cycles Setup

Figure 44. Specimen G Pressurization Cycles Setup

Figure 45. Specimen H Bending Cycles Setup

Figure 46. Specimen H Pressurization Cycles Setup

5.0 COMPARISON WITH PREVIOUS RESULTS

Similar testing was performed previously on unaged baseline Niedner RIFTS conduit under SwRI project number 09.06848. Before comparing the results, there are some differences that should be noted. The burst testing performed in the previous project was a sensitivity study to determine the appropriate specimen length for burst testing. The cyclic testing performed in the previous project was more similar to the current effort, although the specimens typically underwent more pressurization cycles. Some specimens were also subjected to collapse cycles, in which the hose was collapsed after pressurization. However, the results from the cyclic testing showed that the effect of the pressurization and collapse cycles was small compared to that of the bending cycles. For the previous project, fourteen burst tests were performed with an average burst pressure of 2,019 psig. Using a safety factor of 3-to-1, this would yield a nominal working pressure of 650 psig. Based on this value, the working pressure of the aged Niedner RIFTS conduit is approximately 100 psig lower than that of the unaged conduit. In the previous cyclic testing, twelve specimens were subjected to varying amounts of bending and pressurization cycles. The average burst pressure of the cycled specimens was 1,600 psig, representing a 419 psig reduction versus the uncycled specimens. This is a more significant reduction compared to the current results, although the current specimens experienced as many or more bending cycles than did the unaged baseline specimens. Overall, when comparing the uncycled burst results, the aged condition has reduced the working pressure from 650 psig to 550 psig. However, if looking at the cycled burst results, the aged condition is not much different than the unexposed baseline, with only 37 psig separating the average cycled burst pressures.

6.0 LINER EXPANSION

Additional information was requested by TARDEC regarding the apparent expansion of the conduit liner observed during extraction and inspection of the specimens. A ninth specimen, labeled I, was extracted from the same hose reel as the first eight samples. Because the liner had already expanded on the end of the hose reel, the first 15-foot length was cut off as scrap and then Specimen I, approximately 15 feet long, was cut. Immediately after extracting Specimen I, the jacket and liner lengths were measured. Note that the liner had already expanded approximately one inch. These measurements were repeated six times at the intervals noted in Table 7. Over a period of 48-hours from the time of extraction, the liner expanded a total of 3 inches, with the majority of this expansion occurring in the first six hours. Specimen I, just after cutting and then after 48 hours, is shown below in Figure 47 and Figure 48, respectively. Notes from this investigation are presented in Appendix E.

Table 7. Liner Expansion Measurements of Specimen I

Measurement No.	Length of Jacket (inches)	Length of Liner (inches)	Time
1	179 $^{3}/_{4}$	180 $^{3}/_{4}$	Immediately after extraction
2	179 $^{3}/_{4}$	181 $^{1}/_{4}$	1 hour
3	179 $^{5}/_{8}$	181 $^{1}/_{2}$	2 hours
4	179 $^{3}/_{4}$	182 $^{1}/_{8}$	4 hours
5	179 $^{3}/_{4}$	182 $^{1}/_{2}$	6 hours
6	179 $^{3}/_{4}$	182 $^{5}/_{8}$	24 hours
7	179 $^{3}/_{4}$	182 $^{3}/_{4}$	48 hours

Figure 47. Specimen I, Immediately after Extraction

Figure 48. Specimen I, 48 Hours after Extraction

7.0 CONCLUSIONS AND RECOMMENDATIONS

Burst and cyclic testing has been performed on aged Niedner RIFTS conduit manufactured in July 2005. The hose had been previously exposed to diesel fuel and was stored in an outdoor environment for approximately 5-6 years. A summary of the results is presented here:

- Eight 15-foot specimens were extracted from a 500-foot reel of aged Niedner RIFTS conduit. Four specimens were used for burst testing in their present condition. Minor damage was noted on two specimens, but neither specimen burst at the damaged location. The other four specimens were first subjected to bending and pressurization cyclic testing, followed by burst testing. Expansion of the liner for each specimen was observed.

- Four specimens (A, B, C, and D) were burst in order to establish the working pressure of the aged conduit using a 3-to-1 safety factor. The average burst pressure of these specimens was 1,692 psig, yielding a nominal working pressure of 550 psig. The remaining specimens (E, F, G, and H) were burst after cyclic testing, with an average burst pressure of 1,563 psig. This represents a 129-psig reduction in burst pressure due to cyclic testing. All specimens failed by way of a longitudinal tear on or near the crease caused when the hose is lying flat.

- Specimens E, F, G, and H were subjected to cyclic testing involving 100 bending cycles and 20 pressurization cycles each. The working pressure of 550 psig was used for the pressurization cycles. Minor wear was noted due to the bending cycles, and the pressurization cycles resulted in the conduit stretching approximately 2" to 4". Three of the specimens failed in the worn region caused by the bending cycles when burst.

- When compared to the testing results from SwRI project number 09.06848, the aged Niedner conduit has a working pressure 100 psig less than that of the unaged baseline conduit. It was also noted that the cyclic testing had less effect on the burst pressure of the aged conduit than the unaged baseline conduit.

- Further documentation of the liner expansion was made. The liner was found to expand immediately after cutting, and expanded a total of three inches per a 15-foot specimen over a period of 48-hours. The majority of this expansion occurred within six hours after cutting.
- As with any experimental data, testing of more specimens would provide more extensive data and a more accurate representation of the performance of the aged Niedner RIFTS conduit. Also, the liner expansion could be investigated further to determine the relationship, if any, between the hose length and the amount of liner expansion.

APPENDIX A

Preparation and Inspection Notes

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TEST ITEM IDEN. TACOM RIFTS Aged Miedner Hose Testing PAGE 1 OF 7

TEST PROCEDURE REF. ______ PROJECT NO.: 14734.15.501

TEST NAME Specimen Preparation and ~~Test~~ Inspection

Date	Time	Initials	Observations
5/9/2011	9:30AM	OH	Brief inspection of hose as it was left behind Bldg. 99. Two reels of hose. Three end fittings visible ... most likely four are present. Hose is clearly aged. Pictures taken. Reels will now be moved to slab on east side of Bldg. 71.
6/6/2011	10:00AM	OH	Hose reels are located behind Bldg. 71. One end fitting was cut from hose by Division 8. We will cut other end fitting (from other reel) and share these for all testing to avoid having to unreel both reels completely. Portable band saw (with blade reversed) will be used to cut hose. Eight (15-foot) pieces will be cut from reel with end fitting still attach (see pictures). This will give (6) test articles plus (2) extra.

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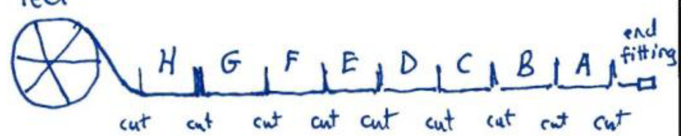
TEST ITEM IDEN. Aged Niedner RIFTS Conduit Testing PAGE 2 OF 7

TEST PROCEDURE REF. ______ PROJECT NO.: 14734.15.501

TEST NAME Specimen Preparation and Inspection

Date	Time	Initials	Observations
6/6/2011	12:00PM	OH	Hose was unreeled and eight specimens, 15-feet each, were cut using bandsaw. Hose was first cut approximately 2 feet from base of end fitting and then the eight (15-foot) specimens were cut. Specimens were labeled A through G as shown below. Again, note that six specimens are required for testing and two are for extra tests if time and budget allows.



all specimens approximately 15-feet.

Next, specimens will be inspected and any damage noted and then specimen A will be assembled with end fittings.

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TEST ITEM IDEN. Aged Niedner RIFTS Conduit Testing PAGE 3 OF 7

TEST PROCEDURE REF. ____________ PROJECT NO.: 14734.15.501

TEST NAME Specimen Preparation and Inspection

Date	Time	Initials	Observations
6/6/2011	2:50pm	O/H	Disassembled end fitting was recovered from Division 8. Cut end of hose with end fitting was disassembled and end fitting removed. All hardware disposed of as new hardware was purchased and old hardware had significant corrosion. Pictures taken of disassembled end fittings. Specimen inspections: A: tear in outer layer, noted in pictures otherwise OK length of Aramid: 15' 1/4" ~~B:~~ length of bladder: 15' 1-1/2" B: no damage noted length of Aramid: 15' length of bladder: 15' 1" C: abrasion of outer layer, noted in pictures otherwise OK loA: 14' 11-1/2" lob: 15' 1-1/4"

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TEST ITEM IDEN. Ayed Niecher RIFTS Conduit Testing PAGE 4 OF 7

TEST PROCEDURE REF. ________ PROJECT NO.: 14734.05.501

TEST NAME Specimen Preparation and Inspection

Date	Time	Initials	Observations
6/6/2011	3:30 PM	OH	D: no damage noted loA (length of Aramid): 15' lob (length of bladder): 15' 1-½" E: no damage noted loA: 15' ¼" lob: 15' 2" F: no damage noted loA: 15' ½" lob: 15' 1-¾" G: no damage noted loA: 15' ¼" lob: 15' 1-½" H: no damage noted loA: 15' ½" lob: 15' 2-¼" All dimensions are approximate. Other than being dirty, hose specimens seem to be in good condition, other than damage noted on A and C.

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TEST ITEM IDEN. Aged Niedner RIFTS Conduit Testing PAGE 5 OF 7

TEST PROCEDURE REF. ______ PROJECT NO.: 14734.15.501

TEST NAME Specimen Preparation and Inspection

Date	Time	Initials	Observations
6/6/2011	4:00PM	OH	It should be noted that ~~bladders~~ the bladder of each specimen seems to have expanded. The specimens were cut as close as possible to 15', yet the bladders measure longer and stick out of the Aramid jacket. It is unknown whether this is due to heat exposure or some other cause. This can be reinvestigated in the morning when it's cooler (it was approximately 100°F this afternoon).
6/7/2011	10:00AM	OH	The bladders had not contracted this morning, meaning it is probably not temperature related. Perhaps just the stress relief of cutting the hose into short pieces. Regardless, the excess bladder will be cut off when the end fittings are installed. Additional pictures taken, particular of damage to A and C. Measurements of damage: Specimen A: damaged 60" from end Specimen C: damaged 9" from end See pictures

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TEST ITEM IDEN. Ageel Niedner RIFTS Conduit Testing PAGE 6 OF 7

TEST PROCEDURE REF. ______ PROJECT NO.: 14734.15.501

TEST NAME Specimen Preparation and Inspection

Date	Time	Initials	Observations
6/7/2011	2:00 PM	OH	Assembling end fittings onto specimen A for burst testing. Following procedure titled "End Fitting Assembly" for this project. All end fitting assemblies between tests will follow same procedure. Extra pictures will be taken as it will be representative of all tests. Any anomalies will be noted and photographed for this assembly and all future assemblies.
6/7/2011	4:30 PM	OH	End fittings have been assembled onto Specimen A. Torquing bolts to 60 ft.-lbs. proved to be too much: one bolt was broken and another was stripped. It was decided to reduce torque to 45 ft.-lbs. to prevent damaging hardware. Burst testing will show if this torque is sufficient to prevent failure of end fitting, but 60 ft.-lbs. is too much for the L9 hardware.

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TEST ITEM IDEN. Aged Niedner RIFTS Conduit Testing PAGE 7 OF 7

TEST PROCEDURE REF. ______ PROJECT NO.: 14734.15.501

TEST NAME Specimen Preparation and Inspection

Date	Time	Initials	Observations
6/17/2011	4:30PM	OH	Torque wrench used for all end fitting assemblies: AN: 011768 SN: 4050325131 Calibrated: May 17, 2011 due: Nov. 17, 2011 One end fitting had a plugged port and the other had a pressure tap w/cap and a rubber cushion (see pictures). The pressure tap will be replaced with a plug in order to prevent potential damage to the port and/or end fitting (due to clearance or obtrusion of pressure tap and rubber cushion). This concludes specimen preparation and inspection. End fitting assembly will follow same procedure for all test specimens.

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APPENDIX B

Pressure Transducer Calibration

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TEST ITEM IDEN. Aged Niedner RIFTS Conduit Testing PAGE 1 OF 2

TEST PROCEDURE REF. ________ PROJECT NO.: 14734.15.501

TEST NAME Pressure Transducer Calibration

Date	Time	Initials	Observations
6/8/2011	5:00PM	OH	Pressure transducer calibration using dead weight tester.
			data point — voltage
			0 psig — 0.021 V
			1000 psig — 1.019 V
			2000 psig — 2.019 V
			3000 psig — 3.025 V
			4000 psig — 4.029 V
			5000 psig — 5.033 V
			4000 psig — 4.029 V
			3000 psig — 3.024 V
			2000 psig — 2.020 V
			1000 psig — 1.019 V
			0 psig — 0.021 V

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TEST ITEM IDEN. Aged Niedner RIFTS Conduit Testing PAGE 2 OF 2

TEST PROCEDURE REF. ______ PROJECT NO.: 14734.15.501

TEST NAME Pressure Transducer Calibration

Date	Time	Initials	Observations
6/8/2011	5:30 PM	OH	Linear trendlines: slope up ⇒ 997.26 x − 17.424 slope down ⇒ 997.32 x − 17.568 average ⇒ 997.29 x − 17.496 Verify: data point — pressure reading 500 psig — 500.6 psig 1500 psig — 1497.6 psig 0 psig — 3.1 psig Equipment: OmegaDyne Pressure Transducer Model PX329-5KG5V Serial 060908D330 Ashcroft Portable Gauge Tester Serial 2NH-91314 Asset 000749 Calibrated 5/12/2011 Due 5/12/2012 pictures taken and data saved

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Oliver Hannon

APPENDIX C

Test Data Sheets

Aged Niedner RIFTS Conduit Hydrostatic Burst Test Datasheet

Conduit Test Sample Number: A	Date: 6/9/2011 1:40 PM
Date of Manufacture: 07-2005	

Prerequisite:

Visual Inspection Notes: end fittings torqued to 45 ft-lbs.

see preparation notes

Calibration Information:

Pressure Transducer: Omega PX329-5KG5V	Temperature at Test Time:
Mod# S/N: 060908D330	End 1: 94.3 °F west
Cal Date: 6/8/2011	Ambient: 93 °F
Cal Due Date: 12/8/2011	End 2: 94.1 °F east

Hydrostatic Burst Test

Conduit Length (LOA): 182 1/2 (in)	Length between Shank Ends: 171 7/8 (in)
Peak Pressure (psig): 1504 psig	Failure Mode: longitudinal tear near end fitting
Data Filename: "BurstA"	Video Record (Circle) Yes / No
Video Tape ID # "Burst A"	

Test Notes/Observations:

tear at base of end fitting

failure occurred on crease along length of hose

approximate measurements

* camera cable was separated when conduit failed, need to secure cable to walls of tank

7" tear

west

east

|←9"→|

Conduit Section – Indicate Burst Location

Testing Personnel:

[signature]	6-9-11	[signature]	6/9/2011
Test Technician(1)	Date	Test Engineer	Date
[signature]	6/9/11		
Test Technician(2)	Date		

pressurization rate began at ~ 400 psi/min and was increased to ~ 1800 psi/min

Shoot for the middle next test

3

Aged Niedner RIFTS Conduit Hydrostatic Burst Test Datasheet

Conduit Test Sample Number: B	Date: 6/10/2011 8:50 AM
Date of Manufacture: 07-2005	

Prerequisite:

Visual Inspection Notes: end fittings torqued to 40 ft-lbs.

see preparation notes

Calibration Information:

Pressure Transducer: Omega PX 329-5KG5V	Temperature at Test Time:
Mod# S/N: 060908 D 330	End 1: 80.1 °F west
Cal Date: 6/8/2011	Ambient: 79.1 °F
Cal Due Date: 12/8/2011	End 2: 82.2 °F east

Hydrostatic Burst Test

Conduit Length (LOA): 180 (in)	Length between Shank Ends: 170 (in)
Peak Pressure (psig): 1610 psig	Failure Mode: longitudinal tear along crease in hose
Data Filename: "BurstB"	Video Record (Circle) Yes / No
Video Tape ID # "Burst B"	

Test Notes/Observations:

approximate measurements

pressurization rate ~ 1400 psi/min (reduce just slightly for next test)

failure occurred along crease in hose from laying flat and being on a reel

9" tear

west ← 22' → east

Conduit Section – Indicate Burst Location

Testing Personnel:

[signature]	6-10-11	[signature]	6/10/2011
Test Technician(1)	Date	Test Engineer	Date
[signature]	6/10/2011	east tether was torn at failure and should be replaced	
Test Technician(2)	Date		

3

Aged Niedner RIFTS Conduit Hydrostatic Burst Test Datasheet

Conduit Test Sample Number: C	Date: 6/10/2011 11:00 AM
Date of Manufacture: 07-2005	
Prerequisite: Visual Inspection Notes: end fittings torqued to 40 ft-lbs see preparation notes	
Calibration Information:	
Pressure Transducer: Omega PX329-5KG5V Mod# S/N: 060809 D330 Cal Date: 6/8/2011 Cal Due Date: 12/8/2011	Temperature at Test Time: End 1: 81.4 °F west Ambient: 87.5 °F End 2: 82.7 °F east
Hydrostatic Burst Test Conduit Length (LOA): 181 1/2 (in) Peak Pressure (psig): 1886 psig Data Filename: "Burst C" Video Tape ID # "Burst C"	Length between Shank Ends: 171 3/8 (in) Failure Mode: longitudinal tear on crease Video Record (Circle): Yes / No
Test Notes/Observations: approximate measurements same type of failure as "A" and "B" pressurization rate ~1200 psi/min (one more small reduction for next test) 10" tear west | ← 16" → | east Conduit Section – Indicate Burst Location	
Testing Personnel: Ronald E. Mezzy 6-10-11 Test Technician(1) Date [signature] 6/10/2011 Test Technician(2) Date	Oliver Harrison 6/10/2011 Test Engineer Date

3

Aged Niedner RIFTS Conduit Hydrostatic Burst Test Datasheet

Conduit Test Sample Number: D	Date: 6/10/2011 3:20 PM
Date of Manufacture: 07-2005	

Prerequisite:

Visual Inspection Notes: end fittings torqued to 40 ft-lbs

see preparation notes

Calibration Information:

Pressure Transducer: Omega PX329-5KG5V	Temperature at Test Time:
Mod# S/N: 0608090330	End 1: 85.5°F west
Cal Date: 6/8/2011	Ambient: 97.8°F
Cal Due Date: 12/8/2011	End 2: 85.7°F east

Hydrostatic Burst Test

Conduit Length (LOA): 181 1/2 (in)	Length between Shank Ends: 171 1/4 (in)
Peak Pressure (psig): 1767 psig	Failure Mode: longitudinal tear on crease
Data Filename: "Burst D"	Video Record (Circle): Yes / No
Video Tape ID # "Burst D"	

Test Notes/Observations:

pressurization rate ~ 1100 psi/min (good

approximate measurements

same type of failure as before

10" tear

west ← 33" → east

Conduit Section – Indicate Burst Location

Testing Personnel:

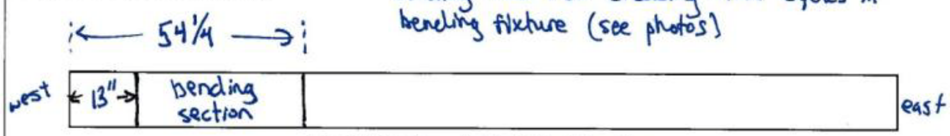
[signature]	6/10/2011	Oliver Yarmin	6/10/2011
Test Technician(1)	Date	Test Engineer	Date
N/A			
Test Technician(2)	Date		

3

Aged Niedner RIFTS Conduit Bending and Pressure Cyclic Tests Datasheet

Conduit Test Sample Number: E	Date: 6/13/2011 8:50 AM
Date of Manufacture: 07-2005	
Prerequisite end fittings torqued to 40 ft-lbs. Visual Inspection Notes: see preparation notes	
Calibration Information	
Pressure Transducer: Omega PX329-5KG5 ✓ Mod# S/N: 060809D330 Cal Date: 6/8/2011 Cal Due Date: 12/8/2011	Temperature at Test Time: End 1: 93.1°F west End 2: 90.6°F east Ambient: 99°F
Bending Cyclic Test Conduit Length (LOA): 178 (in) Data Filename: N/A Time at 50 Cycles: 10:29 AM	 Length between Shank Ends: 168 (in) Start Time: 10:07 AM Time at 100 Cycles: 10:54 AM
Pressure Cyclic Test Conduit Length (LOA): 182 (in) LOA after 20 Cycles: 186 1/16 (in) Data Filename: "CycleE" Video Tape ID # N/A	 Length between Shank Ends: 171 5/8 (in) Length between Shank Ends: 175 5/16 (in) after 20 cycles Video Record (Circle): Yes No

Test Notes/Observations bending has new creasing from cycles in bending fixture (see photos)



Conduit Section – Indicate Bend Locations

Testing Personnel:

Donald 7. Mosz 6-13-11
Test Technician(1) Date

Oliver Hanson 6/13/2011
Test Engineer Date

[signature] 6/13/2011
Test Technician(2) Date

4

Aged Niedner RIFTS Conduit Hydrostatic Burst Test Datasheet

Conduit Test Sample Number: E	Date: 6/13/2011 2:30 PM
Date of Manufacture: 07-2005	

Prerequisite

Visual Inspection Notes: end fittings torqued to 40ft. lbs.

see preparation notes
specimen stretched due to pressure cycling; stretched fibers noted on west end at edge of bending section (see photos)

Calibration Information

Pressure Transducer: Omega PX329-5KG5V	Temperature at Test Time:
Mod# S/N: 0608090330	End 1: 94.1°F west
Cal Date: 6/8/2011	Ambient: 99.6°F
Cal Due Date: 12/8/2011	End 2: 95.7°F east

Hydrostatic Burst Test

Conduit Length (LOA): 186 1/16 (in)	Length between Shank Ends: 175 15/16 (in)
Peak Pressure (psig): 1324 psig	Failure Mode: longitudinal tear on crease
Data Filename: "Burst E"	Video Record (Circle): Yes / No
Video Tape ID #: "Burst E"	

Test Notes/Observations

approximate measurements

pressurization rate: ~1300 psi/min (reduce slightly before next test)

similar failure as before occurred in bending section

did not occur at stretched fibers noted after pressure cycles

8" tear

west ←— 41" —→| east

Conduit Section – Indicate Burst Location

Testing Personnel:

[signature]	6-13-11	[signature] Oliver Hanna	6/13/2011
Test Technician(1)	Date	Test Engineer	Date
[signature]	6/13/2011		
Test Technician(2)	Date		

Aged Niedner RIFTS Conduit Bending and Pressure Cyclic Tests Datasheet

Conduit Test Sample Number: F	Date: 6/13/2011 4:20 PM
Date of Manufacture: 07-2005	
Prerequisite Visual Inspection Notes: end-fittings torqued to 40 ft-lbs. See preparation notes	
Calibration Information	
Pressure Transducer: Omega PX329-5KG5V Mod# S/N: 060809D330 Cal Date: 6/8/2011 Cal Due Date: 12/8/2011	Temperature at Test Time: End 1: 81.3°F west End 2: 83.2°F east Ambient: 80°F
Bending Cyclic Test	
Conduit Length (LOA): 179 (in)	Length between Shank Ends: 169 (in)
Data Filename: N/A	Start Time: 4:30 PM
Time at 50 Cycles: 4:47PM	Time at 100 Cycles: 5:06 PM
Pressure Cyclic Test started pressure cycles 6/14/2011 9:05 AM	
Conduit Length (LOA): 182 (in)	Length between Shank Ends: 172 (in)
LOA after 20 Cycles: 184 ½ (in)	Length between Shank Ends: 174 ¼ (in) after 20 cycles
Data Filename: "Cycle F"	Video Record (Circle): Yes / No
Video Tape ID #: N/A	

Test Notes/Observations

new creases added in bending section due to bending cycles

← 54" →

west | bending section | ← 13" → | east

Conduit Section – Indicate Bend Locations

Testing Personnel:

[illegible]	6-14-11	[illegible]	6/14/2011
Test Technician(1)	Date	Test Engineer	Date
[illegible]	6/14/2011		
Test Technician(2)	Date		

4

Aged Niedner RIFTS Conduit Hydrostatic Burst Test Datasheet

Conduit Test Sample Number: F	Date: 6/14/2011 9:22 AM
Date of Manufacture: 07-2005	

Prerequisite

Visual Inspection Notes: end fittings torqued to 40 ft-lbs.

See preparation notes

specimen stretched some due to pressure cycles; no damage to fibers was noted

Calibration Information

Pressure Transducer: Omega PX329-5KG5V	Temperature at Test Time:
Mod# S/N: 0608090330	End 1: 81.9°F west
Cal Date: 6/8/2011	Ambient: 89.8°F
Cal Due Date: 12/8/2011	End 2: 83°F east

Hydrostatic Burst Test

Conduit Length (LOA): 184 1/2 (in)	Length between Shank Ends: 174 1/4 (in)
Peak Pressure (psig): 1712 psig	Failure Mode: longitudinal tear on crease
Data Filename: "BurstF"	Video Record (Circle): Yes / No
Video Tape ID # "Burst F"	

Test Notes/Observations approximate measurements

pressurization rate ~ 1000 psi/min

similar failure as all others; did not occur in bending section

10" tear

west ← 83" → east

Conduit Section – Indicate Burst Location

Testing Personnel:

Donald E. [signature] 6-14-11 Test Technician(1) Date

Oliver [signature] 6/14/2011 Test Engineer Date

[signature] 6/14/2011 Test Technician(2) Date

5

Aged Niedner RIFTS Conduit Bending and Pressure Cyclic Tests Datasheet

Conduit Test Sample Number: G	Date: 6/14/2011 10:45 AM
Date of Manufacture: 07-2005	

Prerequisite

Visual Inspection Notes: end fittings torqued to 40 ft-lbs. see preparation notes

Calibration Information

Pressure Transducer: Omega PX309-5KG5V	Temperature at Test Time:
Mod# S/N: 0608090330	End 1: 87.9°F west End 2: 93.3°F east
Cal Date: 6/8/2011 Cal Due Date: 12/8/2011	Ambient: 99.7°F

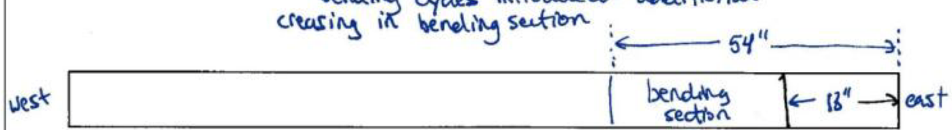
Bending Cyclic Test

Conduit Length (LOA): 179 (in)	Length between Shank Ends: 169 (in)
Data Filename: N/A	Start Time: 10:57 AM
Time at 50 Cycles: 11:15 AM	Time at 100 Cycles: 11:33 AM

Pressure Cyclic Test

Conduit Length (LOA): 181 7/8 (in)	Length between Shank Ends: 171 5/8 (in)
LOA after 20 Cycles: 184 3/4 (in)	Length between Shank Ends: 174 5/8 (in) after 20 cycles
Data Filename: "Cycle G"	Video Record (Circle): Yes / No
Video Tape ID # N/A	

Test Notes/Observations bending cycles introduced additional creasing in bending section



Conduit Section – Indicate Bend Locations

Testing Personnel:

Donald T. Massey	6-14-11	Oliver Yancun	6/14/2011
Test Technician(1)	Date	Test Engineer	Date
[signature]	6/14/2011		
Test Technician(2)	Date		

4

Aged Niedner RIFTS Conduit Hydrostatic Burst Test Datasheet

Conduit Test Sample Number: G	Date: 6/14/2011 2:08 PM
Date of Manufacture: 07-2005	

Prerequisite

Visual Inspection Notes: end fittings torqued to 40 ft-lbs.

see preparation notes

similar stretching of specimen due to pressure cycles; no damage noted

Calibration Information

Pressure Transducer: Omega PX329-5KG5V	Temperature at Test Time:
Mod# S/N: 060809D330	End 1: 91.8°F west
Cal Date: ~~#~~ 6/8/2011	Ambient: 100°F
Cal Due Date: 12/8/2011	End 2: 95.2°F east

Hydrostatic Burst Test

Conduit Length (LOA): 184 3/4 (in)	Length between Shank Ends: 174 5/8 (in)
Peak Pressure (psig): 1680 psig	Failure Mode: longitudinal tear in crease
Data Filename: "Burst G"	Video Record (Circle): Yes No
Video Tape ID #: "Burst G"	

Test Notes/Observations

approximate measurements

similar failure as all others occurred in bending section

east tether broke upon failure

10" tear

pressurization rate ~ 1300 psi/min (valve position was not changed, though)

west ← 27" → east

Conduit Section – Indicate Burst Location

Testing Personnel:

[signature]	6-14-11	Olivier Harisson	6/14/2011
Test Technician(1)	Date	Test Engineer	Date
[signature]	6/14/2011		
Test Technician(2)	Date		

5

Aged Niedner RIFTS Conduit Bending and Pressure Cyclic Tests Datasheet

Conduit Test Sample Number: H	Date: 6/14/2011 3:40 PM
Date of Manufacture: 07-2005	

Prerequisite

Visual Inspection Notes: end fittings torqued to 40 ft.-lbs. see preparation notes

Calibration Information

Pressure Transducer: Omega PX329-5KG5V	Temperature at Test Time:
Mod# S/N: 0608090330	End 1: 81.7°F west End 2: 83.7°F east
Cal Date: 6/8/2011 Cal Due Date: 12/8/2011	Ambient: 82.7°F

Bending Cyclic Test

Conduit Length (LOA): 181 (in)	Length between Shank Ends: 170 1/4 (in)
Data Filename: N/A	Start Time: 4:00 PM
Time at 50 Cycles: 4:18 PM	Time at 100 Cycles: 4:36 PM

Pressure Cyclic Test started pressure cycles 6/15/2011 8:57 AM

Conduit Length (LOA): 184 (in)	Length between Shank Ends: 173 1/4 (in)
LOA after 20 Cycles: 187 (in)	Length between Shank Ends: ~~177~~ 176 1/2 (in) after 20 cycles
Data Filename: "CycleH"	Video Record (Circle): Yes No
Video Tape ID #: N/A	

Test Notes/Observations some creases present due to bending cycles but not as prominent as others

55"

west 13" bending section east

Conduit Section – Indicate Bend Locations

Testing Personnel:

[illegible]	6-15-11	[illegible]	6/15/2011
Test Technician(1)	Date	Test Engineer	Date
[illegible]	6/16/2011		
Test Technician(2)	Date		

4

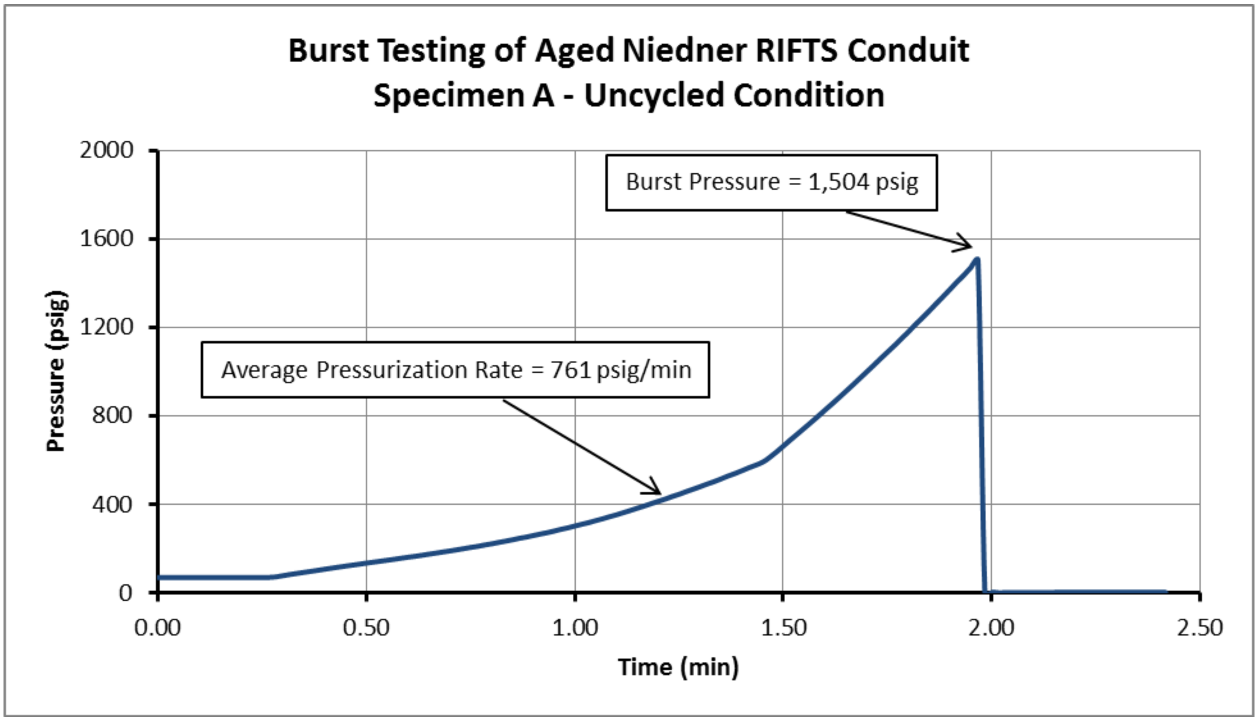
Aged Niedner RIFTS Conduit Hydrostatic Burst Test Datasheet

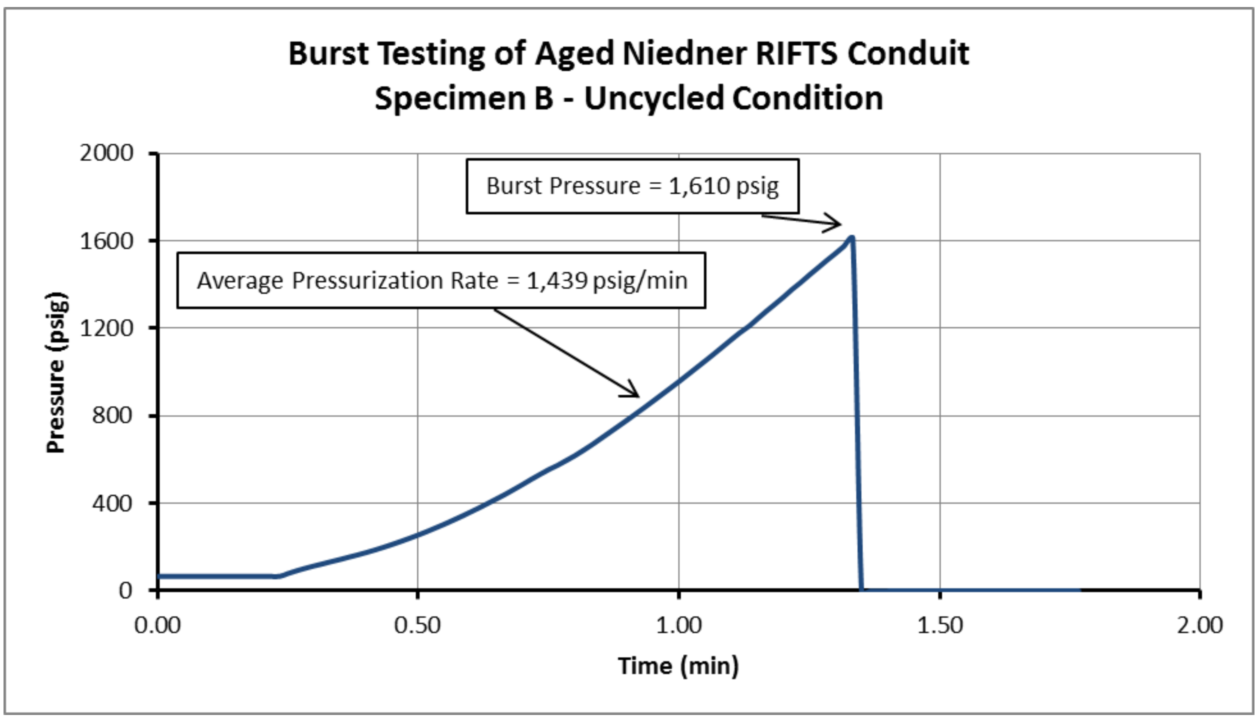
Conduit Test Sample Number: H	Date: 6/15/2011 9:32 AM
Date of Manufacture: 07-2005	
Prerequisite Visual Inspection Notes: end fittings torqued to 40 ft-lbs. see preparation notes same stretching of the specimen as before due to pressure cycles no damage noted	
Calibration Information	
Pressure Transducer: Omega PX329-5KG5V	Temperature at Test Time:
Mod# S/N: 060809D330	End 1: 82.5°F west
Cal Date: 6/8/2011	Ambient: ~~[illegible]~~°F 84.4°F
Cal Due Date: 12/8/2011	End 2: 83.8°F east
Hydrostatic Burst Test	
Conduit Length (LOA): 187 (in)	Length between Shank Ends: 176 1/2 (in)
Peak Pressure (psig): 1534	Failure Mode: longitudinal tear on crease, but bladder tear was different; it seemed to blow-out of the tear in the jacket
Data Filename: "Burst H"	Video Record (Circle): Yes / No
Video Tape ID #: "Burst H"	
Test Notes/Observations approximate measurements pressurization rate ~1000 psi/min Failure occurred in bending section 13" tear and bladder blow-out west ← 50" → east Conduit Section – Indicate Burst Location	
Testing Personnel:	
[signature] 6-15-11 Test Technician(1) Date	[signature] 6/15/2011 Test Engineer Date
[signature] 6/15/2011 Test Technician(2) Date	

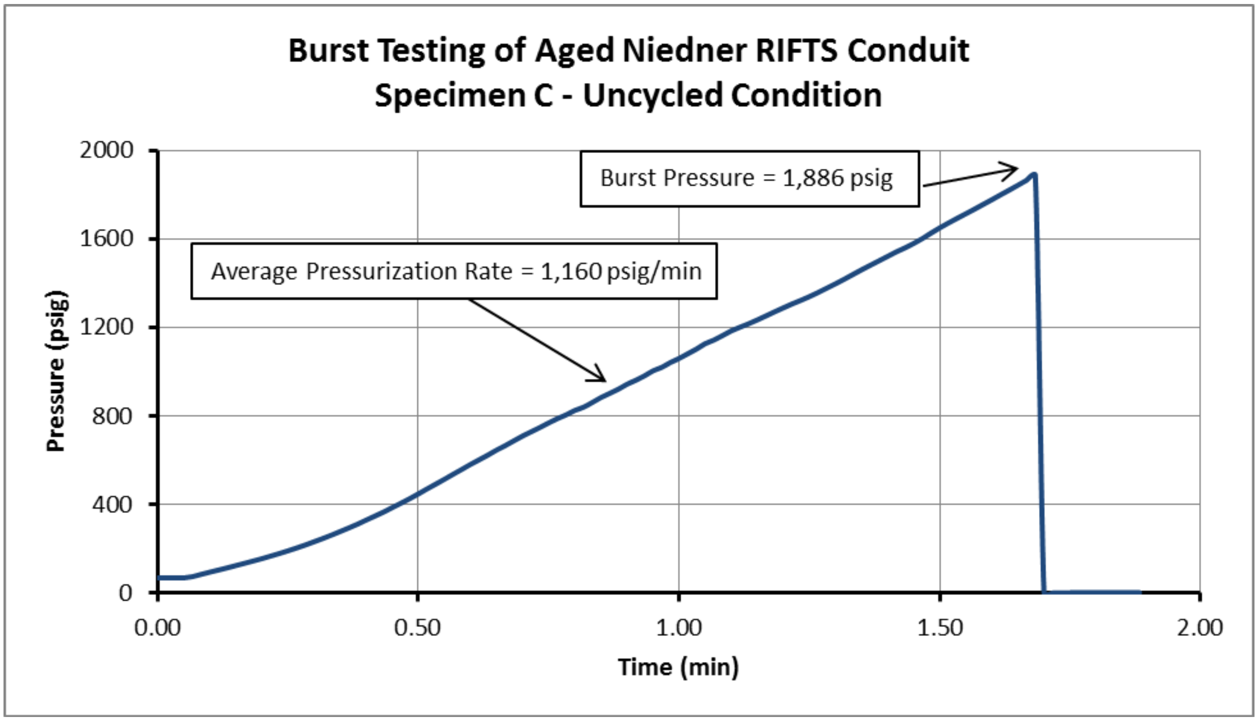
5

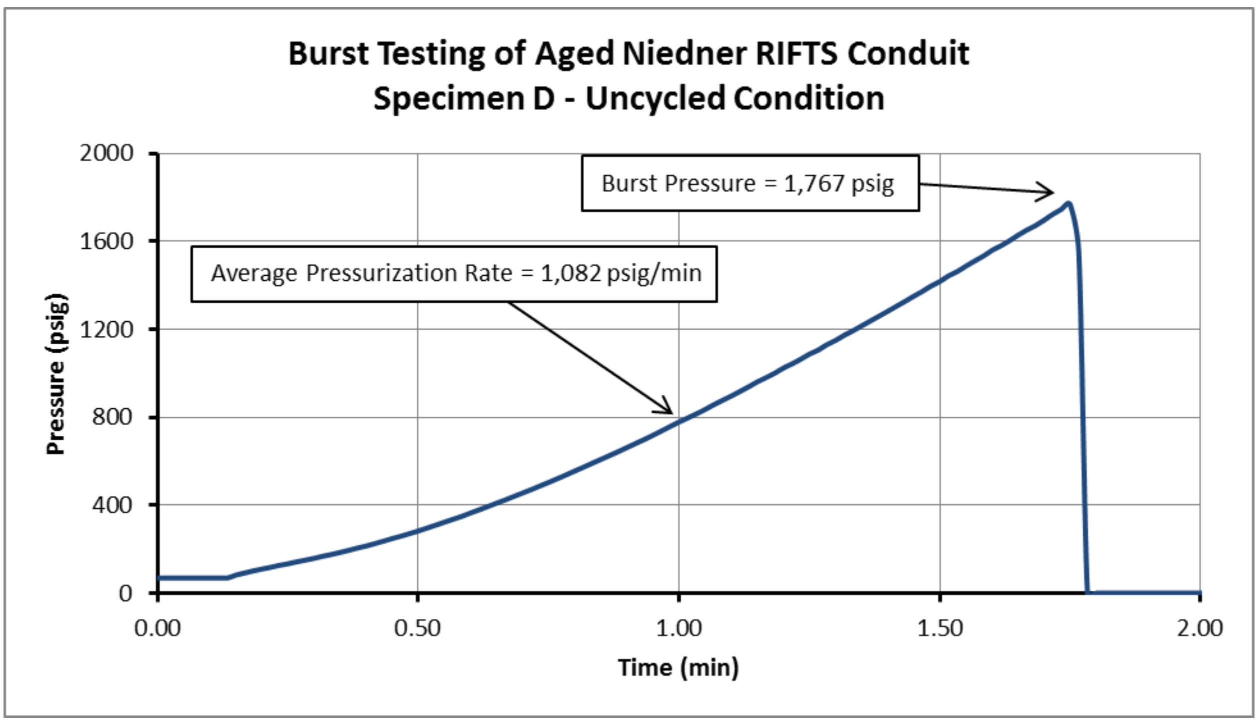
APPENDIX D

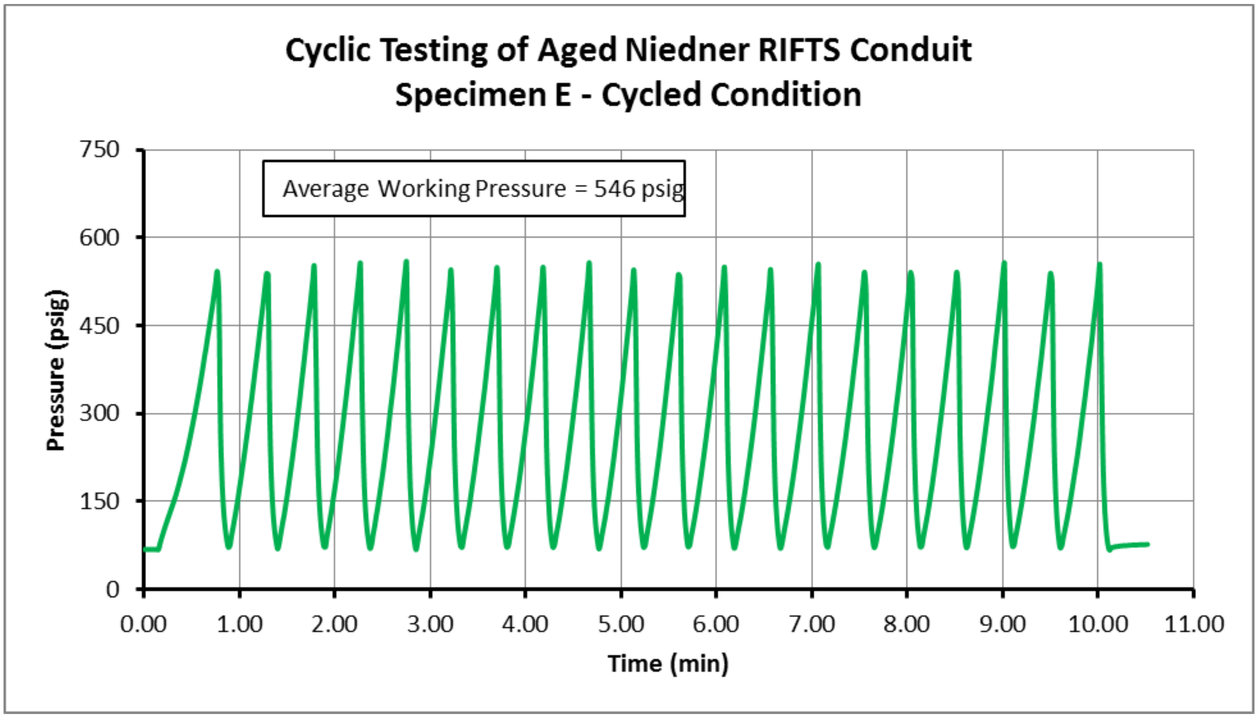
Graphs of Test Data

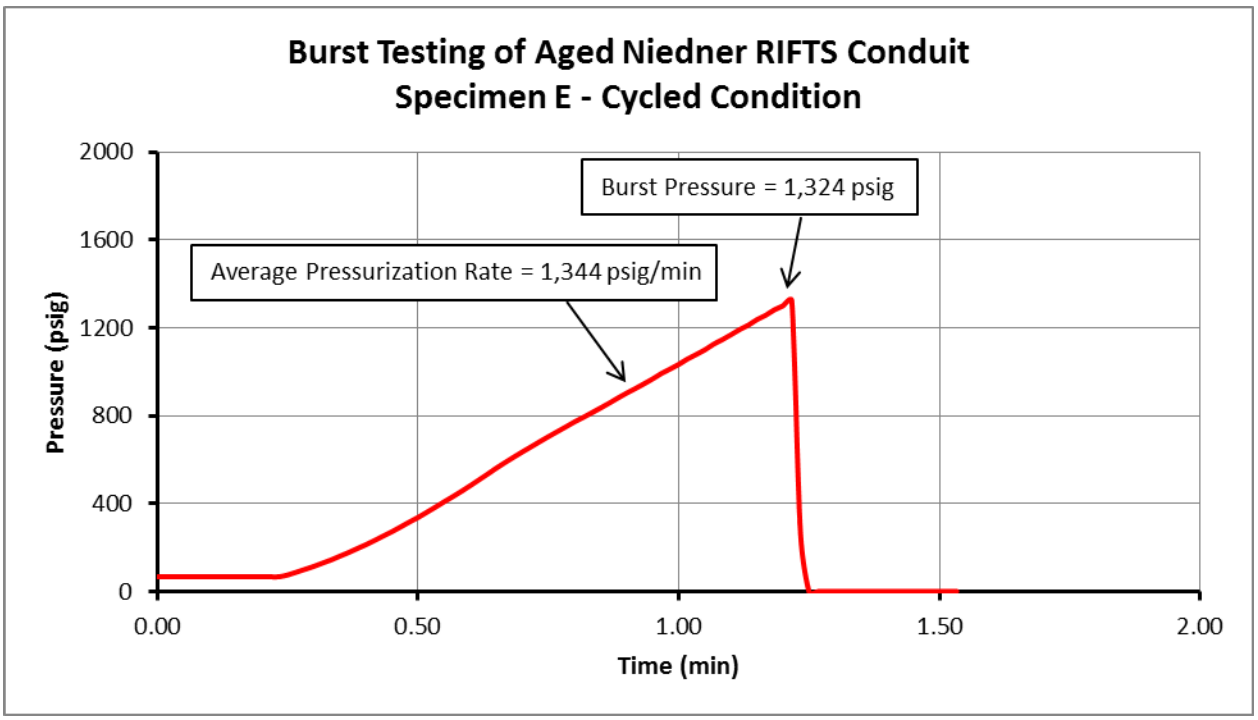

Burst Testing of Aged Niedner RIFTS Conduit
Specimen A - Uncycled Condition
Burst Pressure = 1,504 psig
Average Pressurization Rate = 761 psig/min
Pressure (psig)
2000
1600
1200
800
400
0
0.00
0.50
1.00
1.50
2.00
2.50
Time (min)

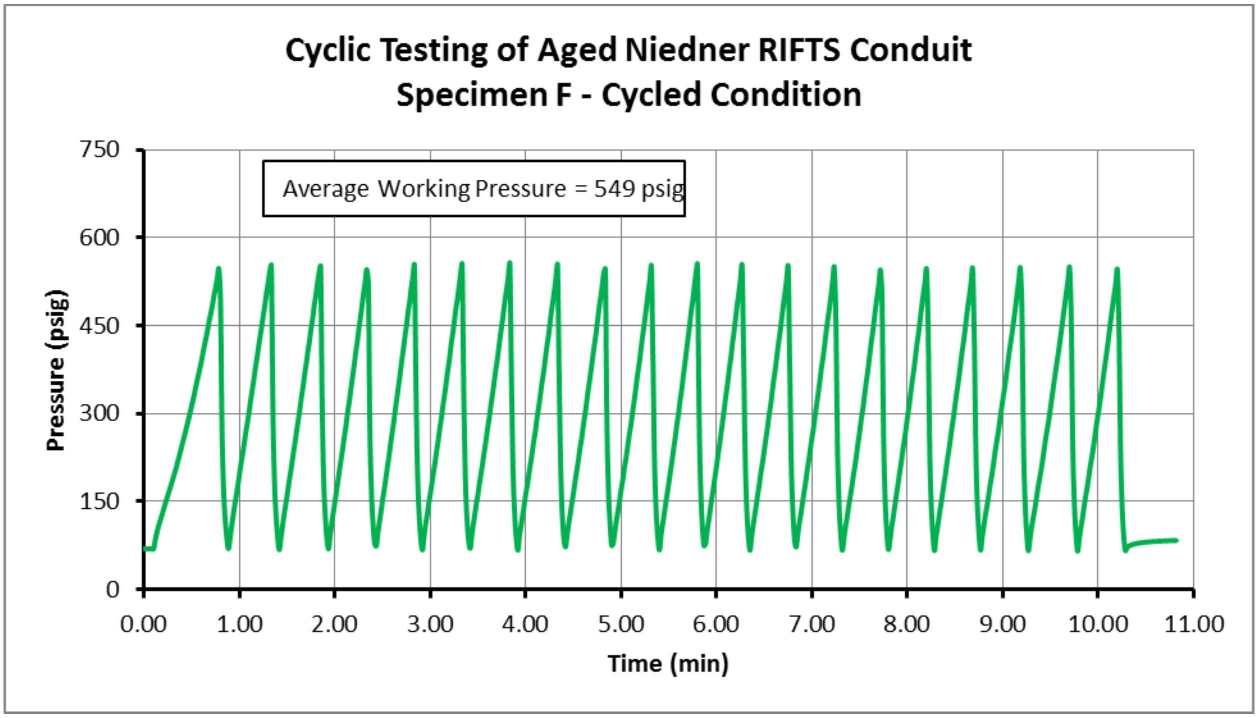

Burst Testing of Aged Niedner RIFTS Conduit
Specimen B - Uncycled Condition
Burst Pressure = 1,610 psig
Average Pressurization Rate = 1,439 psig/min
Pressure (psig)
2000
1600
1200
800
400
0
0.00
0.50
1.00
1.50
2.00
Time (min)

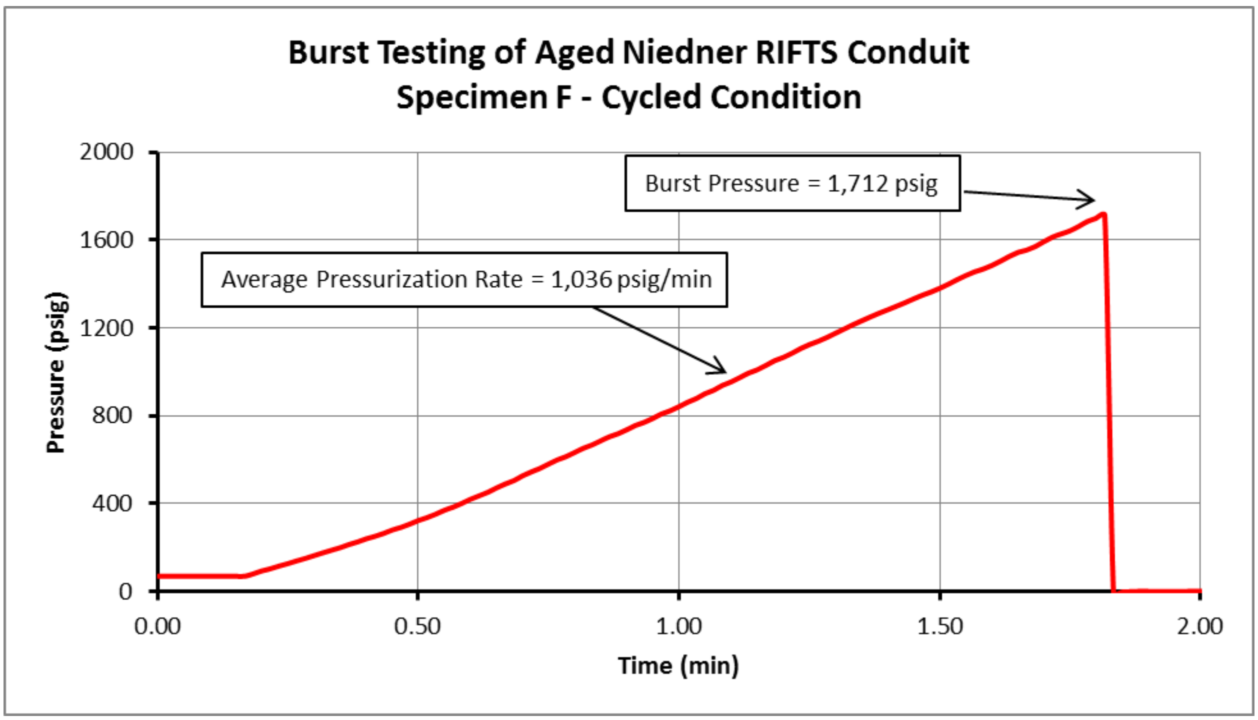

Burst Testing of Aged Niedner RIFTS Conduit
Specimen C - Uncycled Condition
Burst Pressure = 1,886 psig
Average Pressurization Rate = 1,160 psig/min
Pressure (psig)
2000
1600
1200
800
400
0
0.00
0.50
1.00
1.50
2.00
Time (min)

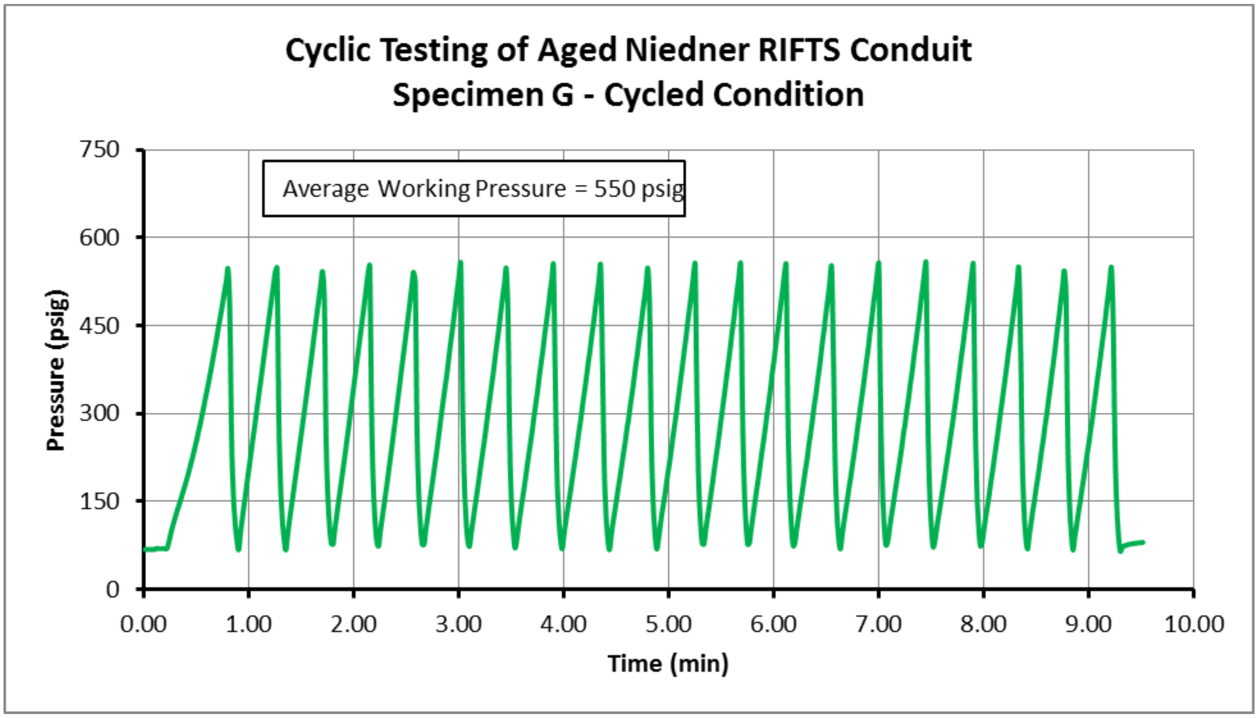

Burst Testing of Aged Niedner RIFTS Conduit
Specimen D - Uncycled Condition
Burst Pressure = 1,767 psig
Average Pressurization Rate = 1,082 psig/min
Pressure (psig)
2000
1600
1200
800
400
0
0.00
0.50
1.00
1.50
2.00
Time (min)

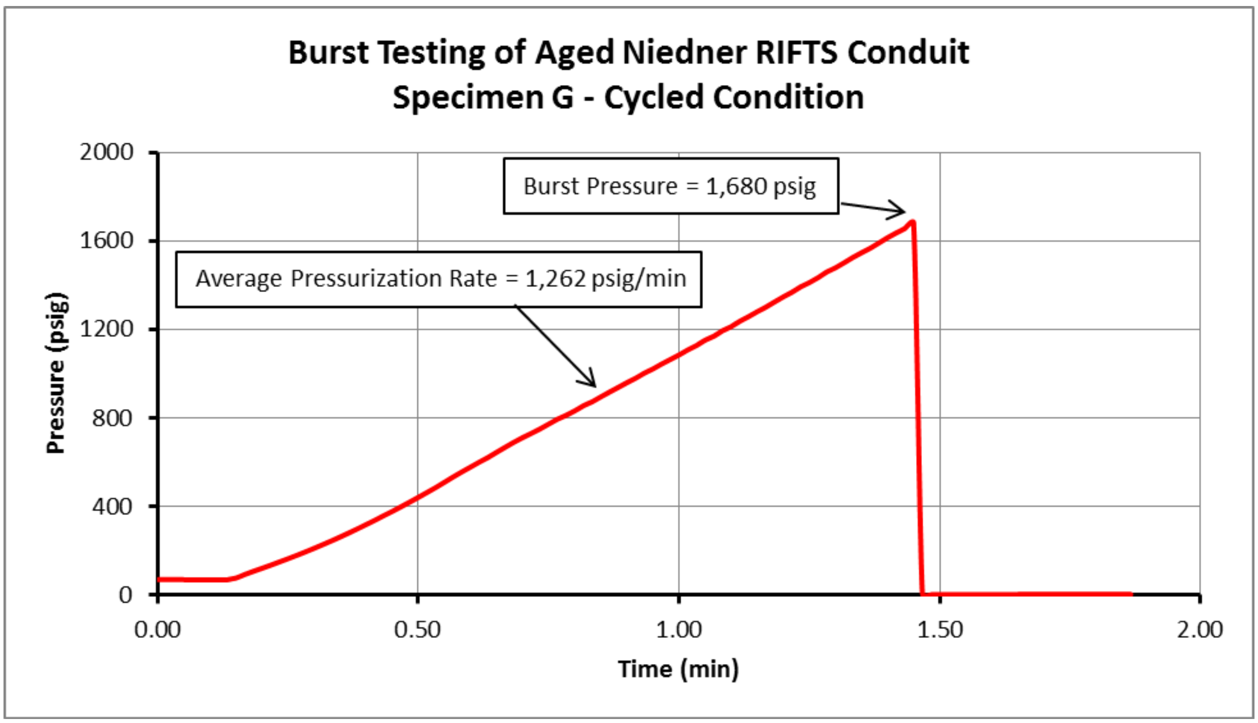

Cyclic Testing of Aged Niedner RIFTS Conduit
Specimen E - Cycled Condition
Average Working Pressure = 546 psig
Pressure (psig)
750
600
450
300
150
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
Time (min)

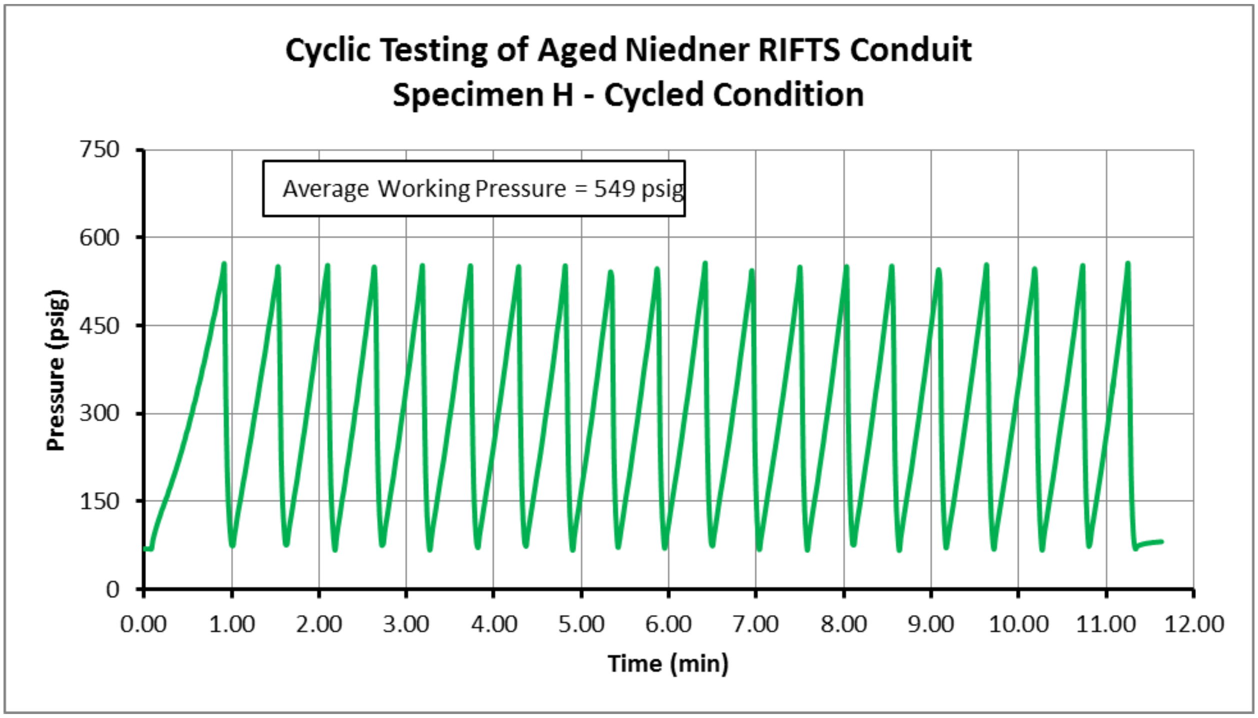

Burst Testing of Aged Niedner RIFTS Conduit
Specimen E - Cycled Condition
Burst Pressure = 1,324 psig
Average Pressurization Rate = 1,344 psig/min
Pressure (psig)
2000
1600
1200
800
400
0
0.00
0.50
1.00
1.50
2.00
Time (min)

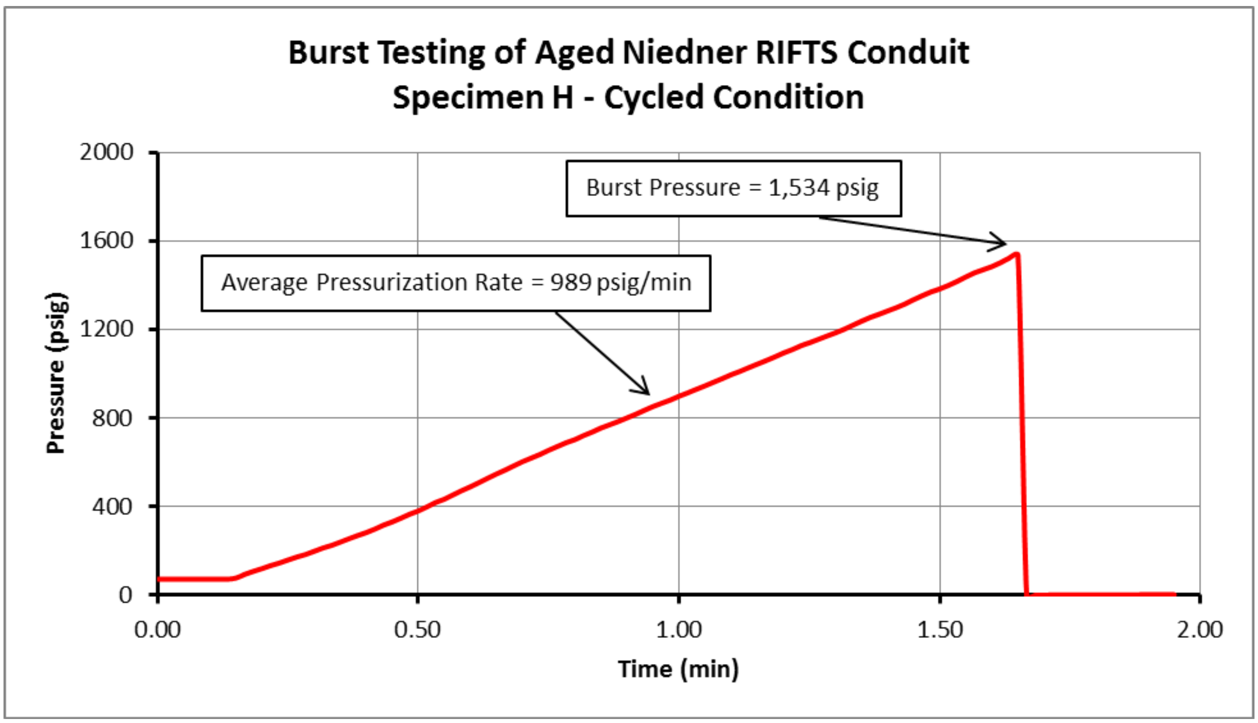

Cyclic Testing of Aged Niedner RIFTS Conduit
Specimen F - Cycled Condition
Average Working Pressure = 549 psig
Pressure (psig)
750
600
450
300
150
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
Time (min)


Burst Testing of Aged Niedner RIFTS Conduit
Specimen F - Cycled Condition
Burst Pressure = 1,712 psig
Average Pressurization Rate = 1,036 psig/min
Pressure (psig)
2000
1600
1200
800
400
0
0.00
0.50
1.00
1.50
2.00
Time (min)


Cyclic Testing of Aged Niedner RIFTS Conduit
Specimen G - Cycled Condition
Average Working Pressure = 550 psig
Pressure (psig)
750
600
450
300
150
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Time (min)


Burst Testing of Aged Niedner RIFTS Conduit
Specimen G - Cycled Condition
Burst Pressure = 1,680 psig
Average Pressurization Rate = 1,262 psig/min
Pressure (psig)
2000
1600
1200
800
400
0
0.00
0.50
1.00
1.50
2.00
Time (min)


Cyclic Testing of Aged Niedner RIFTS Conduit
Specimen H - Cycled Condition
Average Working Pressure = 549 psig
Pressure (psig)
750
600
450
300
150
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
Time (min)


Burst Testing of Aged Niedner RIFTS Conduit
Specimen H - Cycled Condition
Burst Pressure = 1,534 psig
Average Pressurization Rate = 989 psig/min
Pressure (psig)
2000
1600
1200
800
400
0
0.00
0.50
1.00
1.50
2.00
Time (min)

APPENDIX E

Liner Expansion Notes

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TEST ITEM IDEN. Ageel Niedner RIFTS Conduit Testing PAGE 1 OF 3

TEST PROCEDURE REF. ______ PROJECT NO.: 14734.15.501

TEST NAME Investigation of Liner Expansion / Jacket Contraction

Date	Time	Initials	Observations
6/27/2011	8:15AM	OH	Client wishes for further investigation of liner expansion and/or jacket contraction that was noted before. Procedure will be as follows. Unreel hose (same reel) and mark cut lines at approximately 15 feet from the end and then precisely measured 15 feet further. Label end piece as scrap and indicate which samples were on each end (H and I). Label measured specimen "I". Cut specimen "I" out using band saw and immediately measure length of jacket and liner. Make measurements at center of hose. Repeat these measurements at 1, 2, 4, and 24 hours from time of cut. If changes are still occurring, repeat once more at 48 hours. All measurements should be made carefully with an uncertainty of no more than +/- 1/8". Document with photos. Record measurements and times below. Measure on flattest surface possible.

F-DL - Rev. 2

Oliver Harrison

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TEST ITEM IDEN. Aged Niedner RIFTS Conduit Testing PAGE 2 OF 3

TEST PROCEDURE REF. ______ PROJECT NO.: 14734.15.501

TEST NAME Investigation of Liner Expansion / Jacket Contraction

Date	Time	Initials	Observations
6/27/2011	9:21AM	OH	measurements just after cutting: length of Aramid (jacket) 179 3/4 in. length of bladder (liner) 180 3/4 in. * measurements were made within one minute of cutting and liner was already beginning to stick out past jacket.
	10:22AM		Measurements @ 1 hour: loA 179 3/4 in. lob 181 1/4 in.
	11:23AM		measurements @ 2 hours: loA 179 5/8 in. lob 181 1/2 in. * jacket may have shrunk slightly, although this is also within our uncertainty limits, so it's hard to tell.
	1:24PM		measurements @ 4 hours: loA 179 3/4 in. lob 182 1/8 in. * liner is still expanding, so another measurement will be added at 6 hours from cutting.

F-DL - Rev. 2

Oliver Harrison

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TEST ITEM IDEN. Aged Niedner RIFTS Conduit Testing PAGE 3 OF 3

TEST PROCEDURE REF. ______ PROJECT NO.: 14734.15.501

TEST NAME Investigation of Liner Expansion / Jacket Contraction

Date	Time	Initials	Observations
~~6/28/2011~~ 6/27/2011	3:24 PM	OH	Measurements @ ~~24~~ 6 hours: 10A 179 3/4 in. 10b 182 1/2 in.
6/28/2011	9:24AM		measurements @ 24 hours: 10A 179 3/4 in. 10b 182 5/8 in. * slight change from yesterday's last measurement; repeat once more at 48 hours.
6/29/2011	9:23AM		Measurements @ 48 hours: 10A 179 3/4 in. 10b 182 3/4 in. Far majority of change occurred in first 6 hours, with only an additional 1/4" after 48 hours. This concludes investigation of liner expansion, and shows that jacket does not contract. Just to note, there were large amounts of residual water (and some diesel) in the two pieces cut (more so than previous specimens).

F-DL - Rev. 2

Oliver Harrison